

ADVANCES IN ASSIMILATION OF SATELLITE-BASED PASSIVE MICROWAVE OBSERVATIONS FOR SOIL MOISTURE ESTIMATION

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1. INTRODUCTION

Satellite-based microwave measurements have long shown potential to provide global information about soil moisture. The European Space Agency (ESA) Soil Moisture and Ocean Salinity (SMOS, [1]) mission as well as the future National Aeronautics and Space Administration (NASA) Soil Moisture Active and Passive (SMAP, [2]) mission measure passive microwave emission at L-band frequencies, at a relatively coarse (40 km) spatial resolution. In addition, SMAP will measure active microwave signals at a higher spatial resolution (3 km). These new L-band missions have a greater sensing depth (of ~5cm) compared with past and present C- and X-band microwave sensors. ESA currently also disseminates retrievals of SMOS surface soil moisture that are derived from SMOS brightness temperature observations and ancillary data. In this research, we address two major challenges with the assimilation of recent/future satellite-based microwave measurements: (i) assimilation of soil moisture retrievals versus brightness temperatures for surface and root-zone soil moisture estimation and (ii) scale-mismatches between satellite observations, models and in situ validation data.

2. RETRIEVAL VERSUS RADIANCE ASSIMILATION

SMOS directly observes brightness temperatures at multiple incidence angles. Through inversion of a radiative transfer model, these measurements are converted to soil moisture. SMOS retrievals and simulations with the Goddard Earth Observing System Model Version 5 (GEOS-5) Catchment Land Surface Model (CLSM) show climatological biases that need to be addressed prior to or during data assimilation. We have mitigated these biases through revisions of the GEOS-5 land model parameters. The remaining bias is addressed through cumulative distribution function (cdf)-matching [3] before assimilation with an ensemble Kalman filter. Validation against in situ observations over multiple sites

across the globe show that SMOS retrieval assimilation improves the results for both surface and root-zone soil moisture.

Alternatively, the coupling of a microwave radiative transfer model (RTM) to a land surface model allows the conversion of soil moisture, soil temperature, and vegetation water properties into L-band brightness temperature estimates at the top of the atmosphere, thereby enabling the direct assimilation of brightness temperature observations in a fully consistent system. We show how we optimized our coupled LSM-RTM system to limit biases and discuss how SMOS radiance assimilation compares to retrieval assimilation within the GEOS-5 system.

3. MULTI-SCALE SOIL MOISTURE DATA ASSIMILATION

Coarse-scale radiometer observations often lack details that are relevant for practical applications such as agriculture, flood and drought monitoring and mitigation, public health, etc. We discuss several ways to obtain finer-scale information from coarse observations and how to deal with scale mismatches upon validation: (i) disregard biases due to scale mismatches through anomaly assimilation and validation, (ii) statistically downscale satellite products before assimilation, (iii) dynamically downscale satellite products inside the assimilation system with a 3D (spatially distributed) filter [4,5] and (iv) joint assimilation of finer-scale information, e.g. as can be expected from fine-scale radar measurements from the SMAP mission.

4. CONCLUSIONS

Soil moisture data assimilation systems are challenged by some of the typical features of satellite-based microwave measurements and land model estimates. First, we compare radiance against retrieval assimilation of SMOS observations into the GEOS-5 CLSM, while addressing biases in both. Secondly, we discuss the spatial scale mismatch between satellite observations, model simulations and in situ validation data. Progress in the assimilation of current microwave observations into the GEOS-5 CLSM system is crucial for the development of the planned SMAP L4_SM product.

6. REFERENCES

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